Intermodal exchange stations in the city of Madrid

José Manuel Vassallo · Floridea Di Ciommo · Álvaro García

Abstract The City of Madrid is putting into operation Intermodal Exchange Stations (IESs) to make connections between urban and suburban transportation modes easier for users of public transportation. The purpose of this article is to evaluate the actual effects that the implementation of IESs in the City of Madrid has on the affected stakeholders: users, public transportation operators, infrastructure managers, the government, the abutters and other citizens. We develop a methodology intended to help assess the welfare gains and losses for each stakeholder. Then we apply this methodology to the case study of the Avenida de América IES in the city of Madrid. We found that it is indeed possible to arrive at *win–win* solutions for the funding of urban transportation infrastructure, as long as the cost-benefit ratio of the project is high enough. Commuters save travel time. Bus companies diminish their costs of operation. The abutters gain in quality of life. The private operator of the infrastructure makes a fair profit. And the government is able to promote these infrastructure facilities without spending more of its scarce budgetary resources.

Keywords Urban transportation · Modal exchange · Public–private-partnerships · Operation costs

Introduction

Due to urban sprawl that, along with other factors, prompted growth in levels of motorization, a large number of cities in the world are experiencing a relentless increase in the use

J. M. Vassallo (✉) · F. Di Ciommo · Á. García
Transportation Research Centre (TRANSYT), Universidad Politécnica de Madrid, ETSI Caminos, Canales y Puertos, C/Profesor Aranguren s/n, 28040 Madrid, Spain
e-mail: josemanuel.vassallo@upm.es; jvassallo@caminos.upm.es

F. Di Ciommo
e-mail: fdiciommo@caminos.upm.es

Á. García
e-mail: agarcia@caminos.upm.es

of the private cars. To curb this trend, many authorities are adopting measures to promote the use of public transportation. Those measures consist mostly in increasing the supply of public transportation through investing in new infrastructure, and improving the quality of service. However, budgetary constraints are often an important obstacle to these undertakings.

In Spain, the city of Madrid has been a pioneer in the last few years in the adoption of measures intended to promote public transportation use (Vassallo et al. 2009). One of the most important measures has been the construction of Intermodal Exchange Stations (IESs) to facilitate the links among different public transportation modes, particularly the connection of metropolitan bus services to the subway system. This article describes and assesses a new and original practice, conducted by the Regional Government of Madrid, consisting of privately funding IESs through concession contracts with the private sector.

The objective of this article is to show, using the case study of IESs in Madrid, that it is possible to fund transport infrastructure in urban areas without public subsidies and at the same time, ensuring that the stakeholders involved (users, transport operators, infrastructure concessionaires, abutters, and the government) ultimately gain.

After this introduction, the article is divided into five sections. The first section provides a description of the main features of the public transportation system in the Madrid Metropolitan Area (MMA). The second section characterizes the Public–Private-Partnership (PPP) model for funding IESs in the MMA. The third section establishes a methodology to evaluate the effects of the IESs on the different stakeholders. The fourth section applies the methodology previously defined to the case study of the Avenida de America IES. The fifth section contains the article's conclusions.

Public transportation in Madrid's metropolitan area

Six million inhabitants live in the MMA, in an area of 8,000 km^2 with an average population density of 742 inhabitants/km^2. The GDP per capita of the MMA is 30% above the average for the European Union. The MMA used to consist of a single compact center, Madrid City. In the last three decades, however, loosely connected conurbations have been expanding at a much more rapid rate than Madrid City. Consequently, the population in the MMA has been relentlessly spreading out. The City Center still has a high population density, but it decreases as one moves farther away toward the municipalities on the periphery of the MMA. The rate of car ownership in the MMA is almost 700/1,000 inhabitants, which is the highest motorization rate among the Spanish regions. The phenomenon of the suburbanization of both residence and employment along with the increase in car ownership is prompting new transportation trends in the MMA (Monzón et al. 2007). The mobility survey for the MMA shows that from 1996 to 2004 the number of mechanized trips increased by 52%, whereas the population increased only by 14% (Vassallo et al. 2009). It is worth noting how the relationships between the City Centre and the peripheral zones of the MMA are the only origin–destination pairs in the MMA where the market share of public transportation has increased during that period.

The public transport system in the MMA is made up of four modes. Two of them are the typical urban modes (subway and urban buses), and the other two are mostly metropolitan modes (commuter rail and MB). Public transport demand reached 1.64 billion trips in 2008. The market share for each public transportation mode in 2008 was: subway, 42.8%, urban bus, 26%, MB, 16.2% and commuter rail, 15%.

The subway system is managed and operated by a public sector company called Metro de Madrid. The commuter rail system is operated by a business unit of the Spanish railway company (RENFE cercanías). MB, which link Madrid City with the Municipalities in the MMA, are privately owned. The operation of each one of those lines is conducted independently under an exclusive concession contract with the Regional Government of Madrid for a period of between 5 and 10 years. At the time of writing this paper, there were 44 concession contracts for regional buses in the MMA operated by 33 different private companies. Urban buses, however, are managed and operated by a public company, owned by the municipality, called EMT. Unlike the metropolitan bus companies, the EMT is a public not-for-profit company, so profit maximization is not such an important objective for the EMT. However, the CRTM enters into an agreement with the EMT every year in order to monitor its potential deficit.

In addition to that, there is the public service provided by taxis, and managed by individual taxi drivers who own licenses. The availability of licenses is subject to a quota imposed by the Regional Government of Madrid. The Inner city of Madrid has 15,646 taxis, while the MMA allows for 16,079 taxis.

A key element of the public transportation supply in the MMA is its integrated policy. The first level of integration is the institutional (Di Ciommo 2002). The integration of the different public authorities involved in the transport system was reached through the creation, in 1985, of a new public entity called "Consorcio Regional de Transportes de Madrid" (CRTM) aimed at coordinating metropolitan transportation policies in the MMA. The second level of integration took place in the fare structure. To this end, a monthly flat fare valid for use among all the public transport modes in the Region of Madrid was established. The third level of integration was the physical integration of the various transport modes. Since the creation of the CRTM, large infrastructure investments have been made to improve the physical connection among modes through the construction of IESs. These facilities have contributed greatly to improving coordination among the different transportation modes.

A PPP approach for funding IESs in Madrid's metropolitan area

What is an IES?

Madrid City Center is connected to the suburbs mainly through several radial highways which, once the boundaries defining the MMA have been crossed, continue to link Madrid with the main cities of Spain on the coast. Most of the MB use these radial highways to bring commuters from the suburbs and satellite cities to the City Center. Once in Madrid City Center, most of the commuters use the metro system or the urban buses to get to their work. Most of the IESs were planned to be located at the intersections of the radial highways, with Madrid's heaviest trafficked circular line (line 6) of the subway system (see Fig. 1). This is often the point where the first set of traffic lights is located and long lines of vehicles form during the peak hours.

An IES consists of a subterranean building, made up of several stories, that facilitates the modal transfer of commuters arriving from the suburbs in MB to both the subway and urban bus networks (Fig. 2 shows the design of the Avenida de America IES). Some IESs connect also to the commuter rail network, and some others are designed to receive interregional coaches as well. The IESs have escalators and elevators connecting the different floors. Moreover, a set of signs are strategically located to guide the users.

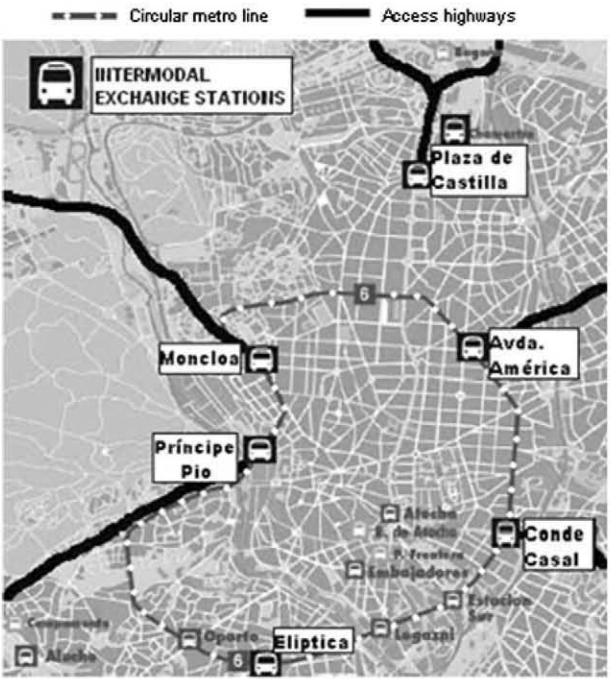

Fig. 1 Map of the IES of Madrid and the principle highways entering into Madrid

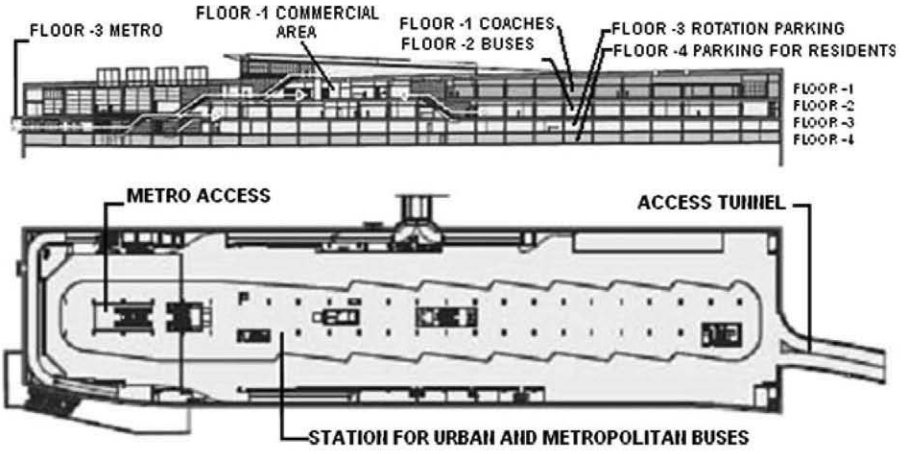

Fig. 2 Map of the Avenida de America IES (front view of the 2nd floor and raised section of the building)

The IESs include space not only for transportation services, but also for shops and restaurants. Adjacent to this building, an access tunnel or a segregated lane is built to help the buses avoid the congestion in the access highways to the City Center. Sometimes the construction of an IES also may include the construction of underground multi-story public parking garages.

Some of the main criteria considered in planning the construction of particular IESs have been the following: its strategic location; the reduction in exchange time for commuters changing from one mode of transport to another; the information systems implemented, especially travel and ticketing information (Grotenhuis et al. 2007); the security measures; the quality of the air and comfort inside the IES; and finally, the supply of complementary services, such as shops and restaurants, that make the transfer time more pleasant for the commuters (Cristóbal and Aldecoa 2002).

The first IES in Madrid, Moncloa, built in 1995, was publicly funded. The success of this exchange station was noteworthy since the construction of a tunnel that avoided congestion in the access highway to Madrid City Center, along with a noticeable improvement in the connections among different public transport modes, led to an increase in demand for public transport in that corridor of more than 30% in only 5 years (1995–2000) (CRTM 2008).

Because of this success, the Regional Government of Madrid intended to undertake the construction of a new IES in Avenida de América, at the entrance to Madrid from the A-2 highway, which experiences heavy traffic in the peak hours. However, at that time, the Regional Government of Madrid did not have enough funding available since costly plans for developing the subway network were just then being put into effect. Owing to this constraint, the Regional Government of Madrid decided to use the concession approach to fund this IES. Spain has long experience in financing other kinds of infrastructure through concession contracts. The Spanish concession law is applicable to every type of public works, including the construction of IESs.

The Regional Government of Madrid entrusted the CTRM with the preparation of the bidding terms and the definition of the subsequent concession contracts. Although the concession approach had a long tradition in Spain, this attempt was a real challenge for the CRTM for two reasons. First, the CRTM did not have any experience with infrastructure concession contracts, and second, the concession approach had never been used before to fund IESs in any city of the world.

The experience with the Avenida de America proved successful. First, the Avenida of America IES was fully funded by the private sector without requiring any subsidy from taxpayers. And second, public transport usage in the corridor increased substantially within only a few years (39% between 2000 and 2006). The annual average growth of the bus demand during this period was 5.66%, much greater that the annual average growth of the private car demand in the corridor, which was 1.78%. This figures show that commuters found public transportation much more appealing once the IES was built.

The annual population growth in the metropolitan corridor of the A-2 highway connecting at the Avenida de America IES was, on average, 3.21% a year between 2000 and 2006 whereas the average annual growth of the population in Madrid City was 1.37% a year. The figures reveal a certain trend toward sprawl. However, it is difficult to demonstrate a significant link between the construction of the IES and the distribution of the population since the sprawl effect has been observable in the MMA for many years long before the IESs were built. A detailed study of this effect would require thorough research to obtain additional results.

Owing to this success, the Regional Government of Madrid decided to undertake a master plan for the construction, maintenance, and operation of several IESs during the period 2004–2007 on the basis of the concession approach. This master plan underlies all three of the new IESs built in Madrid: Plaza Eliptica, Plaza de Castilla and Príncipe Pío, as well as the upgrade and expansion of the Moncloa IES, the first phase of which was completed in 1995. Those IESs were awarded during the last few years to different

Table 1 Main characteristics of the IESs in Madrid

	Intermodal exchange station				
	Avenida de América	Plaza de Castilla	Plaza Elíptica	Príncipe Pío	Moncloa
Capital cost (million Euros)	25.6	102	36	50	97.2
Surface (square meters)	41,500	74,350	29,700	28,300	46,000
Access tunnel (meters)	400	1,250	600	400	1,000
Demand (users/day)	445,400	269,300	126,300	299,200	360,000
Bus shelters	36	45	20	32	36
Number of lines (metrop. buses)	14	37	14	13	35
Number of lines (urban buses)	11	16	10	8	14
Number of lines (metro)	4	3	2	3	2
Number of lines (commuter rail)	0	0	0	2	0
Parking (number of spaces)	665	400			
Concession term (years)	25	35	35	35	35

consortia and only recently have started operation. The shareholders of the consortia are made up of both construction companies and bus operators. Table 1 summarizes the main characteristics of the IESs developed in Madrid under the concession mechanism.

Characteristics of the PPP approach

Many governments are facing increasing challenges to fund public transport infrastructure with scarce budgetary resources (Mayer 2007). To meet this funding gap, policy makers are turning to mechanisms aimed at involving the private sector in managing and financing new and existing infrastructure. Perhaps the most popular mechanism is the concession approach, which consists of transferring responsibility for construction, maintenance, and operation of the infrastructure to a private consortium, in exchange for a user fee for a limited period of time, fixed or variable, but contractually agreed upon in advance (Vassallo and Gallego 2005). Since public infrastructure facilities are often natural monopolies, it is not possible to introduce direct competition in the market. The concession approach is thus a mechanism to introduce competition among private consortia for the market through a competitive tender.

Through the concession approach, the CRTM entrusted to the concessionaire responsibility for the final design, the construction, financing and operation of the IESs and their adjacent tunnels for a period of time fixed in advance, but most often between 20 and 30 years. The concession was competitively awarded in a tender to the best offer presented by the bidders, which is judged in terms of both one economic (the fee to be charged to the bus users) and several technical criteria—previously set out in the bidding documents. The revenues collected by the concessionaire come from four different sources; first, a fee charged to the buses and coaches that use the IES; second, rents from the parking facilities built within the IESs; third, commercial revenues from shops and restaurants within the IES; and fourth, other revenues such as vending machines, advertising rents and so on. However, it has to be recognized that some of the commercial rent receipts could have been obtained without the IES development.

The most important source of revenues comes from the fees that buses (urban buses, MB, and interregional coaches—if the IES is constructed so as to accommodate them) have to pay to the concessionaire to use the IES. The urban and MB are obliged by the CRTM to use the IESs, but the interregional coaches are free to use the IES or not. However, the history of the Avenida de America IES demonstrates that in the end, many companies running interurban coaches decided to take advantage of the IESs.

The fees for urban and regional buses are to be paid by the bus operators to the concessionaire according to the number of passengers that get on and off each bus at the particular IES. Consequently, the greater the number of users, the larger will be the payment by the bus companies to the concessionaire. This way of calculating what bus companies owe is thought to reduce their risk. If they carry a low number of passengers, they will pay less to the concessionaire; if they carry a large number of passengers, they will pay more. The interregional coaches, however, pay a flat fee per coach for using the IES.

Unlike bus and coach companies, neither the subway nor the commuter rail pay any fee for the users that get on and off the subway and rail at the IESs. Two reasons were given for adopting this approach. First, unlike buses, the construction of the IESs does not imply time savings for the metro and the commuter rail. And, second, the subway and the commuter rail are both highly subsidized by the Regional Government of Madrid so that, if they were to be required to pay a fee to the IES concessionaire, the government subsidy would then have to be increased.

The fees per user are set out in the tender process in such a way that the lower the fee offered by one bidder, the greater the probability of that bidder being awarded the concession. Consequently, the fees are strongly related to the financial calculations made by the bidders in terms both of the investment needed to build the IES and the expected demand. This is the reason why there is a large spread in the fees charged by different IES hubs. The fee charged to urban and regional buses varies between €0.06 per passenger in Avenida de América and €0.150 in Principe Pío. Once the contract is awarded, these fees are updated every year to keep up with inflation.

The risk allocation approach was established on the basis of the principles established by the Spanish Concession Law passed in 2003 and modified in 2007, which are the following. First, most of the market risk should be allocated to the private concessionaires. Second, the government should be allocated those risks that cannot be adequately managed by any other stakeholders. Third, the government may assume or mitigate some risks, but this assumption should generally avoid increasing Spain's public deficit. To that end, the Law defines the mitigation as consisting in the main of modifications in the economic parameters (prices, concession term, and so on) initially fixed in the contract.

Up to now, all the IESs promoted in Madrid have been able to raise sufficient financing to be funded solely by means of private capital through the concession approach. Consequently, the Regional Government of Madrid was able to promote this infrastructure without committing any additional budgetary resources of its own. However, it is important to point out that the regional government is renting out city space to improve the transport system. This is not directly related to money, but it might constitute an important resource for public authorities.

Regarding taxes, the IES concessionaire has to pay the same taxes as any other business of its type. On the one hand, the concessionaire will have to pay to the Treasury the difference between the value-added tax received from its clients and the value-added tax paid by its suppliers. On the other hand, the concessionaire will have to pay to the Treasury

the corporate tax, which in the case of Spain amounts to between 30 and 35% of the annual accounting profits of the company.

Effects of the IESs on the stakeholders

In order to evaluate whether the implementation of IESs in Madrid constitutes an adequate urban transportation policy, it is necessary to assess the effects of the IESs on all the various stakeholders affected by them. We identify the following stakeholders: users, transportation operators, abutters and other citizens, IES concessionaires, and the government. Below, we analyze how the utility for each of the stakeholders changes with the implementation of an IES.

Effect on the users

Most of the users of the IESs are people who commute every day from the suburbs of the MMA to Madrid City. To that end, they first take a metropolitan bus and then, once they have arrived in Madrid City, they transfer to the subway or to the urban buses. The IESs reduce the travel time of these users in three different ways. First, the access tunnel and the special bus lanes designed to segregate the buses from the regular traffic help the buses to avoid peak hour congestion, so travel times are reduced. Second, as travel times are reduced, additional use of public transportation is encouraged and, consequently, the bus frequency has to be raised to meet an ever-rising demand. As a consequence of the higher frequency of buses, users reduce their waiting times at the bus stops. This fosters an even greater use of the MB and the whole public transportation system (Jara-Díaz et al. 2008). Third, the modal transfer time for the users is reduced since, thanks to the IES, users do not have to cross any street and the signs available inside the IES facilitate the modal connection. The IES is designed to make easier for users the connection among the various modes of transportation that link up at the station. In addition, the concentration of the urban, metropolitan, and interregional bus stops inside the same building (see Fig. 2) minimizes the modal exchange time. Before the construction of the station, these bus stops were located on the street so the connections were much longer for the users.

In addition to that, the utility of the users increases because, with the IES, their trips become more comfortable. The bus riders do not have to wait for the arrival of the buses on the street where they previously had to endure sometimes difficult weather conditions as well as the pollution caused by the vehicles. Moreover, the users who do have to wait inside the IES for more than a brief period can visit its shops and restaurants, which makes the transfer time more pleasant. These shops are also visited by people living nearby.

Figure 3 illustrates the benefits that the construction of an IES produces in the commuters. The advantages described above improve the quality of the trip so the demand curve rises from D_b to D_a (the subscript b refers to the scenario *before* the IES and the subscript a refers to the scenario *after* IES). To arrive at this conclusion, we assume that there are not short-term adjustments in our analysis but only long-run steady states before and after the introduction of the IES. Moreover, for the sake of simplicity we depict demand curves as linear. However, we note that the reasoning is valid for any kind of decreasing demand curve. As the price p that is charged by the transportation companies to the users remains the same before and after the construction of the IES, the benefit for the users (consumer surplus) will be given by the shaded area in Fig. 3.

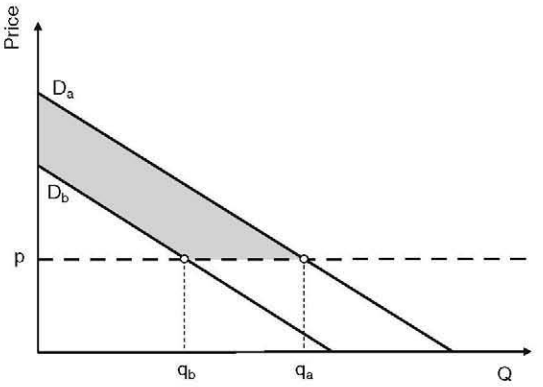

Fig. 3 Benefits produced on the users for the construction of the IES

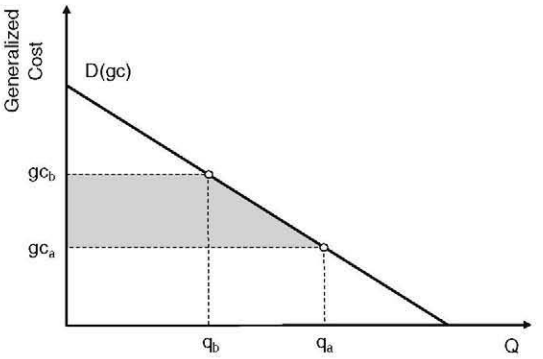

Fig. 4 Practical computation of the benefits produced on the users for the construction of the IES

This area is calculated according to the following equation:

$$B_U = \int_0^{q_b} [D_a(q) - D_b(q)] \cdot dQ + \int_{q_b}^{q_a} [D_a(q) - p] \cdot dq \quad (1)$$

where $D_b(q)$ is the demand curve before the construction of the IES, $D_a(q)$ is the demand curve after the construction of the IES, q is the Flow of passengers in the line, p is the Price charged to the users, q_b is the Flow of passengers in the line before the construction of the IES, and q_a is the Flow of passengers in the line after the construction of the IES.

However, in practice it is difficult to know accurately the shape of the demand curve so, from a practical prospective, the users benefits are approached as the difference between the generalized cost of the users (mostly travel time) before and after the construction of the IES. This is the methodology that we actually apply in the computation of the users' benefits for the Avenida de America case study. The shaded area in Fig. 4 shows how the benefits are calculated in a practical way.

The users' benefits are hence calculated according to the following equation:

$$B_U = (gc_b - gc_a) \cdot (q_b) + \frac{1}{2} \cdot (gc_b - gc_a) \cdot (q_a - q_b) \quad (2)$$

where q_b is the flow of passengers in the line before the construction of the IES; q_a is the flow of passengers in the line after the construction of the IES; gc_b is the generalized cost

for the users before de construction of the IES; gc_a is the generalized cost for the users after de construction of the IES.

Effects on public transport operators

There are several transportation operators affected by the construction of an IES: MB, urban buses, commuter rail, and the subway. The two most important transportation modes in an IES are the metropolitan bus companies and the subway, because most of the users transfer for one of these modes to the other. In this section, we focus first on the case of MB, which is the mode that is most affected, and then we deal with the other transportation modes.

A reduction in travel time also implies important cost reductions for bus companies (Nash 2007). The construction of the tunnel—beginning at a point of the access highway and debouching into the IES—enables MB to realize significant time savings. This tunnel, adjacent to the IES, helps the buses to avoid the congestion caused by vehicles at the first set of traffic lights in entering the city. As a consequence, the operation costs of metropolitan bus companies are reduced because the travel time reduction means that fewer buses are required to provide the same frequency of bus service to meet a certain passenger demand. Fewer buses also mean fewer drivers.

However, as has already been mentioned, it is expected that travel time savings will create a greater demand for the use of MB by consumers, so the frequency of such bus service will have to be increased. In this case, even though the average cost per user will be substantially reduced for reasons that will be discussed below, additional buses would be required to meet the higher demand. Thus, total transport costs will not necessarily be reduced and they might even increase.

Direct costs related to bus operation can be divided between those costs that depend on the kilometers effectively run by the fleet, and those costs that depend on the operation time of the fleet (hours effectively driven). For instance, the wages of the drivers will depend on the number of hours they drive whereas the depreciation of the buses and the fuel consumption will be related to the number of kilometers actually travelled by the bus fleet.

The number of buses necessary to meet a certain demand of users is estimated according to the following equation:

$$n = \frac{q}{S \cdot V} \cdot 2L \tag{3}$$

where n is the number of buses needed to serve a flow of passengers q; q is the flow of passengers in the line (passengers/h); S is the occupancy of the buses (passengers/bus) calculated as the maximum capacity of the buses times the average utilization ratio, V is the average speed of the bus in the cycle route (km/h), and $2L$ is the length of the cycle of the bus.

The total cost of the bus operators per hour is often calculated—see for instance Ministerio de Fomento (2006)—according to Eq. 4:

$$C_T = a + c_t \cdot n + c_l \cdot n \cdot V \tag{4}$$

where C_T is the total cost per hour (€/h); a is the indirect costs (€/h); c_t is the direct cost per time unit (€/h × bus); c_l is the direct cost per length unit (€/km × bus); n is the number of buses in the fleet and V is the Average speed in the line (km/h).

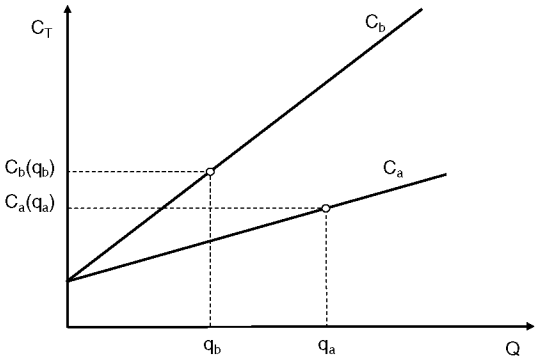

Fig. 5 Total cost of the bus operators before and after the construction of the IES

Introducing Eq. 3 in Eq. 4 it is easy to obtain Eq. 5:

$$C_T = a + \frac{2L \cdot q}{S} \cdot \left[\frac{c_t}{V} + c_l\right] \tag{5}$$

According to the hypotheses described before, this equation shows how the total cost C_T linearly increases with the flow of passengers q to be served by the bus company. However, for the same flow of passengers q, the higher the average speed in the line the lower will be the total cost. This is because the higher the average speed the smaller the fleet will be. For this reason, the C_T curve—after the IES has been built—will be less steep than before. This effect is shown graphically in Fig. 5.

From Eq. 5 it is easy to estimate the average cost (ac) (see Eq. 6) and the marginal cost (mc) (see Eq. 7). The ac decreases with q. The mc is constant with q, but for a specific value of q it decreases with the average speed V. In other words, the increase of the average speed implies the greater efficiency of the bus company.

$$\text{ac} = \frac{C_T}{q} = \frac{a}{q} + \frac{2L}{S} \cdot \left[\frac{c_t}{V} + c_l\right] \tag{6}$$

$$\text{mc} = \frac{dC_T}{dq} = \frac{2L}{S} \cdot \left[\frac{c_t}{V} + c_l\right] \tag{7}$$

From Eq. 7, it is easy to calculate the mc reduction for the bus operators as a result of the construction of the IES. We observe that the mc reduction depends only on the direct cost per time unit c_t, the time savings and the average occupancy per vehicle.

$$\Delta\text{mc} = \text{mc}_a - \text{mc}_b = \frac{c_t}{S} \cdot [t_a - t_b] \tag{8}$$

The surplus gained by the metropolitan bus companies if they had not been required to pay a fee for using the IES would be represented by the shaded area of Fig. 6. The surplus can be easily calculated as $(\text{mc}_b - \text{mc}_a) \cdot q_b + (p - \text{mc}_a) \cdot (q_a - q_b)$.

However, the MB have to pay to the IES an amount equal to the bus passengers who get on and off the bus at the IES multiplied by the IES fee. The surplus or benefit of the metropolitan bus companies B_O is consequently calculated according to Eq. 9.

$$B_O = [(\text{mc}_b - \text{mc}_a) \cdot q_b + (p - \text{mc}_a) \cdot (q_a - q_b)] - q_a \cdot w \tag{9}$$

The term w is the fee per passenger that the bus companies have to pay to the IES concessionaire. The CRTM has required metropolitan bus companies to pay this fee

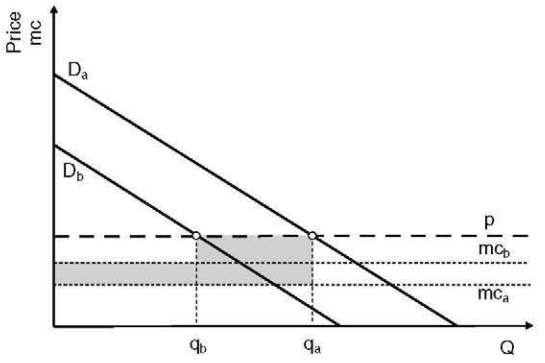

Fig. 6 Surplus for the bus operators before and after the construction of the IES

without increasing the fares they charge to the users, so the value of w should allow B_O to be always positive.

In other words, the operation costs saved by the bus companies should be higher than the amounts those companies pay to the concessionaire. This is the key to explaining how the IESs are funded. The operation cost savings to the metropolitan bus companies throughout the life of the concession enable those companies, through the sums they then transfer to the IES, to help pay off the debt incurred by the shareholders of the IES. In other words, the belief in such a future revenue stream is what initial investors, those who build and maintain the IES, take into account in their original calculations.

Until now, we have focused our analysis on the MB. Let us deal with the rest of the transportation modes. The urban buses, which are operated by a single public municipal company called EMT, are not as important as the metropolitan ones for the IES, since fewer urban lines lead all the way to the IESs. Some of the urban bus lines that arrive at the IES also use the access tunnel so they save travel time just as do the metropolitan lines, but other lines, those that do not use the access tunnel, do not necessarily save travel time. As with the MB, the ultimate benefit for the EMT will depend on the savings in operation costs, the additional revenues collected by the EMT that are a result of the better quality of service and better connections with other transportation modes, and the fee that the EMT has to pay to the IES concessionaire.

Other transportation modes—such as the subway and the commuter rail—are less affected by the construction of the IES because their costs of operation are not reduced by the existence of the IES. However, they can observe that their ridership increases, for the existence of the IES makes transfers to and from them easier, and thus provides them with additional users. Moreover, the metro and the commuter rail do not pay any fee to the IES, and their utility appears at least not to diminish. It would, however, be more sensible to assume that the additional patronage likely to result from connecting to the IES will increase the utility of these lines.

Effects on the abutters and other citizens

The abutters and other citizens are also increasing their utility since they benefit from a better quality of life. The IESs reduce the space occupied by urban MB that, before the existence of the IES, used to stop on the street to leave off passengers. Those buses on the street reduced the capacity of the urban road network, made difficult the transit of the pedestrians, and caused deterioration in the image of the area and in property values.

The construction of the IESs left plenty of available space on the ground, which, now more attractively built up, has substantially improved the image of the urban area around the IES, thus greatly benefitting the abutters and other citizens.

Although no specific study has been conducted to estimate the influence of the IES on the prices of real estate around the IESs, it is expected that those prices will increase, which undoubtedly would benefit the abutters. Di Ciommo (2003) reported that the construction of the Intermodal Station of the Gare du Nord in Paris prompted rent increases in the nearest apartments of around 40% to 50%. However, as has already happened at the Gare du Nord, this effect can accelerate a process of gentrification of the urban area, pushing out the low income abutters to other neighborhoods. This effect depends, however, on the willingness of authorities to avoid preempting real estate goods.

Moreover, as some authors point out, the time saved by the users means both a private benefit for the users and a social benefit for the community (Crozet and Joly 2004; Mackie et al. 2001; Hine and Scott 2000). For instance, the construction of the IES and its adjacent tunnel brings about important environmental benefits as well. First, as the use of buses in the corridor increases, the use of private cars will diminish. This will prompt a reduction of emissions and congestion costs that benefits the abutters and other citizens. And second, after the construction of the IES, the urban environment in the area where the buses used to stop in order to leave off passengers will be substantially improved because the buses that used to stop in the street before the IES was built stop now in a garage underground where air pollution can be more adequately channeled.

Effects on the IES concessionaire and the government

The IES concession is designed so as to make the IES business self-financing for the private sector without any need for public support. The condition set up in Eq. 10 has to be met for this to happen:

$$\begin{aligned} \mathrm{AR} + \sum_{i=0}^{i=m} \frac{Q_{\mathrm{a}}^{i} \cdot w_i}{(1+\alpha)^i} &\geq \sum_{i=0}^{i=m} \frac{I_i + \mathrm{MO}_i + t_i}{(1+\alpha)^i} \\ \alpha &= \frac{E}{E+D} \cdot r_{\mathrm{e}} + \frac{D}{D+E} \cdot r_{\mathrm{d}} \cdot (1-t) \end{aligned} \tag{10}$$

where AR is the additional revenues (shop rents, advertisements, and so on); Q_{a}^{i} is the annual bus passengers in year $i = q_{\mathrm{a}}^{i} \times$ (hours of operation year i); w_i is the fee per passenger to be paid to the IES concessionaire; I_i is the investment or capital cost in year i; MO_i is the maintenance and operation cost in year i; t_i is the corporate taxes paid by the IES in year i, m is the duration of the concession contract in years; α is the weighted average cost of capital; D is the debt value of the firm; E is the equity value of the firm; r_{e} is the cost of equity; r_{d} is the cost of debt.

The IES concessionaire is supposed to make some profit. Obviously, no entity would ever have bid for the concession in the first place unless a future profit would be derived from the awarding of that concession. According to the concession contract terms, the concessionaire takes on many risks, such as construction, operation and demand risk. Consequently, the profits that the concessionaire ultimately obtains will depend on how the business goes on in the future. The ultimate utility to the concessionaire will depend on the revenues it will obtain from both transportation operators and other sources (shops, parking rents, etc.), as well as on the ultimate construction and operation costs of the IES.

Regarding the government, its role is not to make a profit for its own sake but rather to increase benefits for the whole community. In the case of the IESs, the government itself does not provide any direct subsidy to the concessionaire, but it still holds some of the concession risks such as *force majeure* or the risk of political changes that can prompt legislative modifications of the existing legal framework. In spite of this, the government will still obtain resources through the additional corporate tax and value-added tax revenues that will likely be paid by the IES Company.

The Avenida de America case study

In this section, we conduct an exercise intended to evaluate, according to the methodology outlined before, the case study of the Avenida de America IES. The concession of this IES was awarded in 1998 for a period of 25 years, until 2023. The concession was granted to a consortium made up of two big construction firms (ACS and Ferrovial), two private bus companies (Continental Auto and Trapsa), and one bank (BBVA). The construction started in 1998 and the actual operation started in 2000, so there is enough of a track record to enable us to quantify the costs and benefits derived from its being put into operation.

The concession included the construction of the subterranean building and its adjacent tunnel. The fee to be paid by urban and MB was set up in the tender as €0.06 per passenger in 1998. For coaches, the fee was set up as €10 per coach. The estimated value of shop rents was €50 per square meter even though the concessionaire was free to negotiate this value with the stores.

The CRTM (2007) reported that the construction of the Avenida de América IESs and their adjacent tunnels and segregated lanes, which were included as part of the assets of the concession, enabled metropolitan and urban buses on average to save 7.5 and 3 min per trip, respectively. This savings in travel time resulted in substantial demand growth ratios during the first few years of the concession.

Table 2 shows a summary of the way we have calculated the social benefit produced by the construction of the IES. Even though the concession lasts from 1998 to 2023, for the sake of simplicity the table shows only the yearly benefits from 1998 to 2006 where real data are already available. We have also calculated the net present value (NPV) for the society discounted at the social discount rate used in Spain, which is 4.8% (Souto 2003). In order to complete this calculation, we have taken on the estimates from 2007 to the end of the concession contract. Table 4 in Appendix, we show in greater detail the calculations we have conducted for this case study.

We estimate the social benefit as the addition of the users' benefits, the operation cost savings of the urban and MB, and the IES concessionaire benefits. We have not considered the travel time savings of the interurban buses that use the station because we do not have enough information about that. Moreover, for the sake of simplicity, we do not analyze the effect of some taxes such as value-added taxes (VAT).

First, we conducted an analysis of the users' benefits caused by travel time savings. According to a survey based on revealed preferences, an average travel time value of €8.8 per hour for bus users can be adopted in 2004 (CRTM 2007). Travel time savings are calculated according to Eq. 2. In order to simplify the analysis we considered that the generalized cost for the users before and after the construction of the IES includes only travel time and the public transportation fare that does not change. In 2004, travel time savings for both urban buses and metropolitan bases totaled €3.95 million and €14.39 million respectively (see Table 2).

Table 2 Costs and benefits stemming from the construction of the Avenida de América IES in Madrid from 1998 to 2006 in € million

	*NPV**	1998	1999	2000	2001	2002	2003	2004	2005	2006
USERS (€ million)										
Travel time savings EMT	*74.57*			2.65	3.35	3.85	3.90	3.95	4.27	4.49
Travel time savings MB	*271.92*			9.68	12.21	14.04	14.23	14.39	15.58	16.38
Users' Benefits [A]	*346.49*			12.34	15.56	17.90	18.13	18.33	19.85	20.88
Bus operators (€ million)										
Cost savings EMT	*12.30*			0.44	0.55	0.64	0.64	0.65	0.70	0.74
Cost savings MB	*44.85*			1.60	2.01	2.32	2.35	2.37	2.57	2.70
Fees paid by EMT to the IES	*−12.09*			−0.43	−0.54	−0.62	−0.63	−0.64	−0.69	−0.73
Fes paid by MBs to the IES	*−17.64*			−0.63	−0.79	−0.91	−0.92	−0.93	−1.01	−1.06
Bus operators Benefits [B]	*27.42*			0.98	1.23	1.42	1.44	1.45	1.57	1.65
IES concesionaire (€ million)										
Capital costs	*−24.80*	−7.69	−17.93							
Maintenance and operation costs	*−31.48*			−1.72	−1.77	−1.83	−1.88	−1.94	−1.80	−2.07
Revenues from EMT	*12.09*			0.43	0.54	0.62	0.63	0.64	0.69	0.73
Revenues from MBs	*17.64*			0.63	0.79	0.91	0.92	0.93	1.01	1.06
Revenues interurban buses	*12.38*			0.46	0.49	0.52	0.54	0.56	0.78	0.76
Parking rents	*7.09*			0.37	0.40	0.42	0.44	0.46	0.50	0.44
Commercial rents	*18.31*			0.87	0.93	0.99	1.04	1.08	1.12	1.18
Other revenues	*1.56*			0.03	0.03	0.03	0.03	0.03	0.03	0.11
Corporate taxes	*−2.63*			−0.07	−0.10	−0.12	−0.12	−0.12	−0.16	−0.16
IES Concessionaire Benefit [C]	*10.17*	−7.69	−17.93	0.99	1.31	1.55	1.61	1.65	2.17	2.06

Table 2 continued

	*NPV**	1998	1999	2000	2001	2002	2003	2004	2005	2006
Government (€ million)										
Corporate taxes	*2.63*			0.07	0.10	0.12	0.12	0.12	0.16	0.16
Government Benefit [D]	*2.63*			0.07	0.10	0.12	0.12	0.12	0.16	0.16
Total (€ million)										
Social Benefit [A] + [B] + [C] + [D]	*386.71*	−7.69	−17.93	14.38	18.20	20.98	21.30	21.56	23.76	24.74

* The VAN is calculated from 1998 to 2023

Table 3 Marginal cost reduction versus fee per user charged on the passengers of the urban and MB

€	Marginal cost reduction (2004) Δmc	Fee per user (2004) W
Metropolitan buses	0.0726	0.0714
Urban buses	0.1815	0.0714

After that, we analyzed whether the operation cost reduction compensates for the fee that the bus companies have to pay to the IES concessionaire. According to Eq. 8, we can calculate the marginal cost reduction caused by travel time savings. In 2004, the value of c_t was €45 per hour (Ministerio de Fomento 2006), the average occupancy of the buses $S = 31$, and the travel time savings were 7.5 min for MB and 3 min for urban buses. Introducing those values in Eq. 8 we obtain the results displayed in Table 3. As the marginal cost reduction is greater than the fee per user that the bus companies have to pay to the IES. The companies will be better off after the construction of the IES.

This means that, for the Avenida the América IES, the bus companies can cover the additional fee they have to pay to use the IESs without a surcharge added to the user tickets. However, we note that the benefit is much greater for the metropolitan bus (MB) companies than for the EMT because the travel time savings are much greater for the MB companies. Overall, for the Avenida de América IES we have estimated savings in operation costs which, in 2004, amounted to €1.45 million.

Finally, we estimate the benefit for the IES concessionaire. To that end, in Table 2 we display its revenues and costs. Its costs are mostly capital costs and maintenance and operation costs. Its revenues come from four different sources: revenues from the bus companies that get to the IES (EMT, MB companies and interregional companies), parking rents from a parking built in one of the stories of the IES, commercial rents from shops within the IES, and other revenues. Overall we calculate that the IES concessionaire reach a positive net present value of €10.17 millions. The internal rate of return of the IES concessionaire's cash flows is 7.28%, a figure that is greater than the weighted average cost of capital (5.5%), so the concession is profitable for the private sector. Moreover, the government will receive €2.63 millions (calculated at present value) from corporate taxes over the life of the concession.

The last row of Table 2 shows the net social benefit as the addition of the users' benefit, the bus operators' benefit, the IES concessionaire benefits and the government's benefit. The net present value of this benefit is €386.71 million, which is 15.6 times greater than the capital cost to build the IES facilities. It is noteworthy that the net social benefits are much higher than the capital costs. This is because the IES produces important benefits to the users in terms of travel time savings, while most of the resources to fund the IES come from savings in operation costs of the bus companies.

The analysis conducted previously is very conservative in its estimate of benefits, since many of these have not been quantified, such as both the operation savings of the inter-regional buses, and the benefits to the abutters in terms of the improvement of the urban environment.

Discussion and conclusion

The implementation of IES concessions in Madrid can be deemed a real success for several reasons. First, these facilities have encouraged the use of public transportation in Madrid with a consequent reduction of congestion and other non-monetized externalities. Second, the IESs have contributed to the reduction of the operation costs of the MB. Third, the IESs have improved the urban environment in areas of the city center that used to be subject to steady deterioration. And fourth, these infrastructure facilities have been able to attract enough investment money so as to be funded solely by means of private capital through the PPP approach. Consequently, the government was able to promote this infrastructure without committing any additional budgetary resources.

The IESs were able to be funded solely through private capital because it was expected that the IESs would be able to raise the necessary revenues to cover their costs. The revenues come from the fees paid by the buses that use the IES, and other additional revenues (shop rents, parking rents, advertisements, vending machines, and so on). The fees paid by the MB are lower than the operation costs they save by using the IESs so the bus companies do not need to raise the fares they charge to the commuters. Moreover, the advantages of the IES for the users in terms of reduction in travel time, increased comfort, and better connections to other urban transportation modes fosters greater usage of the IES, which in turn increases the value of the commercial activities inside the IES. A second issue relating to raising money for the IES consists in taking advantage of the creation of an area where many people gather, or pass through, every day, and thus commercial revenues from stores on-site can be substantial. In addition, some IESs offer public parking for payment, and revenues derived from that help fund the infrastructure as well.

The construction of the IES is thus a good example of a *win–win* strategy. The users are pleased since they save time without paying a larger fare for using the MB. The bus companies are also happy since, even though they now have to pay a fee to the IES concessionaire, this amount is smaller than the transportation costs they save. Moreover, the bus companies are also pleased since travel by bus has substantially increased since the construction of the IES. The concessionaire is pleased since it can take advantage of a profitable business opportunity. The abutters gain in quality of life. The community, and even the country, benefits from a reduction in emissions. And the government is able to promote all that without spending additional sums. However, it is fair to say that this situation is possible because the benefit cost ratio is very large, around 15.6, which permits a split of benefits among many different parties that everyone emerges better off. It is likely that such a result would not be possible were there to be a much lower benefit-to-cost ratio.

Appendix

See Table 4.

Table 4 Calculation of the Benefits produced by the Avenida De America Ies over the life of the concession

	VAN	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Users													
Users/year EMT (million)				6.89	8.41	9.33	9.14	8.97	9.43	9.59	9.88	10.07	10.27
Users/year MB (million)				10.05	12.26	13.61	13.32	13.08	13.75	13.98	14.40	14.69	14.99
Value of time €/hour				7.71	7.97	8.25	8.54	8.80	9.06	9.37	9.70	9.89	10.09
Travel time savings EMT (million €)	74.57			2.65	3.35	3.85	3.90	3.95	4.27	4.49	4.79	4.98	5.18
Travel time savings MB (million €)	271.92			9.68	12.21	14.04	14.23	14.39	15.58	16.38	17.46	18.17	18.90
Users' benefits (million €)	346.49			12.34	15.56	17.90	18.13	18.33	19.85	20.88	22.25	23.15	24.09
Bus operators													
Operation cost savings EMT (million €)	12.30			0.44	0.55	0.64	0.64	0.65	0.70	0.74	0.79	0.82	0.86
Operation cost savings RB (million €)	44.85			1.60	2.01	2.32	2.35	2.37	2.57	2.70	2.88	3.00	3.12
Fees paid by EMT to the IES (million €)	−12.09			−0.43	−0.54	−0.62	−0.63	−0.64	−0.69	−0.73	−0.78	−0.81	−0.84
Fes ppaid by MBs to the IES (million €)	−17.64			−0.63	−0.79	−0.91	−0.92	−0.93	−1.01	−1.06	−1.13	−1.18	−1.23
Bus operators benefits (million €)	27.42			0.98	1.23	1.42	1.44	1.45	1.57	1.65	1.76	1.83	1.91
IES concessionaire													
Capital costs (million €)	−24.80	−7.69	−17.93										
Maintenance and Operation (million €)	−31.48			−1.72	−1.77	−1.83	−1.88	−1.94	−1.80	−2.07	−2.13	−2.19	−2.26
Revenues EMT (million €)	12.09			0.43	0.54	0.62	0.63	0.64	0.69	0.73	0.78	0.81	0.84
Revenues from MBs (million €)	17.64			0.63	0.79	0.91	0.92	0.93	1.01	1.06	1.13	1.18	1.23
Revenues interurban buses (million €)	12.38			0.46	0.49	0.52	0.54	0.56	0.78	0.76	0.79	0.83	0.87
Parking rents (million €)	7.09			0.37	0.40	0.42	0.44	0.46	0.50	0.44	0.45	0.46	0.48
Commercial rents (million €)	18.31			0.87	0.93	0.99	1.04	1.08	1.12	1.18	1.21	1.25	1.28
Other revenues (million €)	1.56			0.03	0.03	0.03	0.03	0.03	0.03	0.11	0.13	0.13	0.14
Corporate taxes (million €)	−2.63			−0.07	−0.10	−0.12	−0.12	−0.12	−0.16	−0.16	−0.17	−0.17	−0.18
IES Concessionaire benefits	10.17	−7.69	−17.93	0.99	1.31	1.55	1.61	1.65	2.17	2.06	2.20	2.29	2.40
Government													
Corporate taxes (million €)	2.63			0.07	0.10	0.12	0.12	0.12	0.16	0.16	0.17	0.17	0.18
Government benefits (million €)	2.63			0.07	0.10	0.12	0.12	0.12	0.16	0.16	0.17	0.17	0.18
Total													
Total (million €)	386.71	−7.69	−17.93	14.38	18.20	20.98	21.30	21.56	23.76	24.74	26.38	27.45	28.57

Table 4 continued

	VAN	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Users															
Users/year EMT (million)		10.48	10.69	10.90	11.12	11.34	11.57	11.80	12.04	12.28	12.52	12.77	13.03	13.29	13.56
Users/year MB (million)		15.29	15.59	15.90	16.22	16.55	16.88	17.21	17.56	17.91	18.27	18.63	19.01	19.39	19.77
Value of time €/hour		10.29	10.50	10.71	10.92	11.14	11.37	11.59	11.82	12.06	12.30	12.55	12.80	13.06	13.32
Travel time savings EMT (million €)	74.57	5.39	5.61	5.84	6.07	6.32	6.58	6.84	7.12	7.40	7.70	8.02	8.34	8.68	9.03
Travel time savings MB (million €)	271.92	19.67	20.46	21.29	22.15	23.04	23.98	24.94	25.95	27.00	28.09	29.23	30.41	31.64	32.91
Users' benefits (million €)	346.49	25.06	26.07	27.13	28.22	29.36	30.55	31.78	33.07	34.41	35.80	37.24	38.75	40.31	41.94
Bus operators															
Operation cost savings EMT (million €)	12.30	0.89	0.93	0.96	1.00	1.04	1.08	1.13	1.17	1.22	1.27	1.32	1.38	1.43	1.49
Operation cost savings RB (million €)	44.85	3.24	3.38	3.51	3.65	3.80	3.95	4.11	4.28	4.45	4.63	4.82	5.02	5.22	5.43
Fees paid by EMT to the IES (million €)	−12.09	−0.87	−0.91	−0.95	−0.99	−1.02	−1.07	−1.11	−1.15	−1.20	−1.25	−1.30	−1.35	−1.41	−1.46
Fes ppaid by MBs to the IES (million €)	−17.64	−1.28	−1.33	−1.38	−1.44	−1.49	−1.56	−1.62	−1.68	−1.75	−1.82	−1.90	−1.97	−2.05	−2.14
Bus operators benefits (million €)	27.42	1.98	2.06	2.15	2.23	2.32	2.42	2.52	2.62	2.72	2.83	2.95	3.07	3.19	3.32
IES concessionaire															
Capital costs (million €)	−24.80														
Maintenance and Operation (million €)	−31.48	−2.32	−2.37	−2.42	−2.47	−2.52	−2.57	−2.62	−2.67	−2.72	−2.78	−2.83	−2.89	−2.95	−3.01
Revenues EMT (million €)	12.09	0.87	0.91	0.95	0.99	1.02	1.07	1.11	1.15	1.20	1.25	1.30	1.35	1.41	1.46
Revenues from MBs (million €)	17.64	1.28	1.33	1.38	1.44	1.49	1.56	1.62	1.68	1.75	1.82	1.90	1.97	2.05	2.14
Revenues interurban buses (million €)	12.38	0.91	0.95	0.99	1.03	1.08	1.12	1.17	1.23	1.28	1.34	1.39	1.46	1.52	1.59
Parking rents (million €)	7.09	0.49	0.51	0.52	0.54	0.55	0.57	0.59	0.60	0.62	0.64	0.66	0.68	0.70	0.72
Commercial rents (million €)	18.31	1.32	1.36	1.40	1.44	1.49	1.53	1.58	1.63	1.68	1.73	1.78	1.83	1.89	1.94
Other revenues (million €)	1.56	0.14	0.15	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.20	0.20	0.21
Corporate taxes (million €)	−2.63	−0.19	−0.20	−0.21	−0.22	−0.23	−0.24	−0.25	−0.27	−0.28	−0.29	−0.31	−0.32	−0.34	−0.35
IES Concessionaire benefits	10.17	2.50	2.63	2.76	2.90	3.05	3.21	3.37	3.53	3.71	3.89	4.08	4.28	4.48	4.70
Government															
Corporate taxes (million €)	2.63	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.27	0.28	0.29	0.31	0.32	0.34	0.35
Government benefits (million €)	2.63	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.27	0.28	0.29	0.31	0.32	0.34	0.35
Total															
Total (million €)	386.71	29.73	30.97	32.25	33.58	34.97	36.41	37.92	39.48	41.11	42.81	44.57	46.41	48.32	50.31

References

Cristóbal, C., Aldecoa, J.: Concepción de terminales estaciones de autobuses metropolitanos en Madrid, Presented at the International Seminar: La integración modal en la grandes aglomeraciones urbanas, Mexico (2002)

Crozet, Y., Joly, I.: Budgets Temps de Transport: Les sociétés tertiaires confrontées à la gestion paradoxale du «bien le plus rare». Les Cahiers Scientifiques du Transport **45**, 27–48 (2004)

CRTMC: Informe sobre la demanda en el Intercambiador de Avenida de América. Internal Report of the Consorcio Regional de Transportes de Madrid, Madrid (2007)

CRTM: Madrid 2007–2008. Referente Mundiál Consorcio Regional de Transportes de Madrid (2008)

Di Ciommo F. "L'accessibilité: l'enjeu prioritaire de la nouvelle politique des transports publics à Naples" in Bernard Jouve, Les politiques de déplacements urbains en Europe, pp. 135–159. L'Harmattan (2002)

Di Ciommo, F.: Le pôle d'échange de la gare du Nord entre intermodalité et régénération urbaine. Case study of "Transport and Sustainable development lessons". Ecole Nationale des Ponts et Chaussées, Paris (2003)

Grotenhuis, J.W., Bart, W.W., Rietveld, P.: The desired quality of integrated multimodal travel information in public transport: customer needs for time and effort saving. Transp. Policy **14**, 27–38 (2007)

Hine, J., Scott, J.: Seamless, accessible travel: users' views of the public transport journey. Transp. Policy **7**, 217–226 (2000)

Jara-Díaz, S.R., Tirachini, A., Cortés, C.E.: Modeling public transport corridors with aggregate and disaggregate demand? J. Transp. Geogr. **16**, 430–435 (2008)

Mackie, P.J., Jara-Diaz, S., Fowkes, A.S.: The value of travel time savings in evaluation. Transp. Res. Part E: Logist. Transp. Rev. **37**, 91–106 (2001)

Mayer, J.: Private returns, public concerns. Addressing private-sector returns in public-private highway toll concessions. transportation research record: J. Transp. Res. Board 1996, 9–16 (2007)

Ministerio de Fomento: Observatorio de costes del transporte de viajeros en autocar. Dirección General de Transporte por Carretera, Madrid (2006)

Monzón, A., Cascajo, R., Pardeiro, A.M., Jordá, P., Pérez, P., Delgado, M.A.: Observatorio de la movilidad metropolitana: Informe 2005. Ministerio de Medio Ambiente, Madrid (2007)

Nash, C.: Road pricing in Britain. J. Transp. Econ. Policy **41**, 135–147 (2007)

Souto, G.: Tasa de descuento para la evaluación de inversiones públicas: Estimaciones para España. Papeles de Trabajo del Instituto de Estudios Fiscales **8**, 1–29 (2003)

Vassallo, J.M., Gallego, J.: Risk-sharing in the new public works concession law in Spain. Transp. Res. Record: J. Transp. Res. Board **1932**, 1–9 (2005)

Vassallo, J.M., Pérez de Villar, P., Muñoz-Raskin, R., Serebrisky, T.: Public transport funding policy in Madrid. Is there room for improvement? Transp. Rev. **29**, 261–278 (2009)